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Zooarchaeology in the Paraná River flood plain: GIS implementation at a regional scale

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Abstract

The aim of this study is to evaluate the use of wildlife resources that human populations which inhabited the Paraná River floodplain during the late Holocene carried out. To that end, zooarchaeological information from 26 archaeological sites analyzed by different research teams was collected. In order to perform the analysis of the composition of the sets, a Geographic Information System (GIS) is used, since this tool facilitates the comparison between the representations of the different *taxa* spatially and temporally. This allows us to establish similarities and differences in the use of wildlife resources carried out by the groups of hunters, gatherers and fishers in the region. Most of the zooarchaeological analyses are performed at a micro-regional level; however, due to the fact that this study is developed at a regional scale, it enables a comprehensive understanding of the structure of the different archaeofaunal assemblages in the diverse landscape units which make up the Parana River floodplain. The application of the GIS to this analysis provides simple graphics to visualize and interpret data and its variations in terms of space.

Keywords: zooarchaeology – regional scale– GIS – Paraná River

1. Introduction

The Paraná River, which is by extension one of the most important rivers in South America, for over 2,000 years, has been home to different populations that settled on its shores and islands in order to make use of the resources offered by this rich environment.

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In Argentina, the Parana River floodplain covers a large area, including the provinces of Santa Fé, Corrientes, Entre Ríos and Buenos Aires. The archaeological evidence found belongs to hunters, gatherers and/or fishermen who inhabited the area for 2,500 years BP until the European-Indian contact (Ceruti 2000). The subsistence economy of these groups would have been based on hunting, gathering and fishing, although populations which had a horticultural component stocks in their diet would have been also found in the region (Loponte and Acosta 2004;Bonomo*et al*., 2011a). During the time of European-Indian contact, the groups that inhabited the area were called with several names (*timbués*; *chanaes*, *corondá*, *guaraní*, etc.), most of which did not respect the original ethnic name. Archaeologists continued using such names, mainly during the early to midtwentieth century; consequently, the material record was correlated to a particular culture. The fact that the emphasis was on ethnic diversity in general and the existing oneof the floodplain of the Parana in particular, was due to the great interest of the researchers to generate a cultural image of the region to order the existing archaeological information. That is why, much of these early investigations focused on the stylistic features of pottery in order to establish similarities and differences that could be ascribed to certain "cultural types" (see for example, Caggiano 1984, Ceruti 1986, 1991, 2000, de Aparicio 1936, Frenguelli 1923, González 1939, Lafón 1971, Outes 1918, Politis y Bonomo 2012, Rodríguez 1986, 1992; Torres 1907). These types or "cultural identities" (*sensu*Ceruti, 1986) were defined based on a specific and characteristic material record, and in turn, delimiting their boundary in a spatio-temporal framework. Therefore, the names of each cultural type usually refer to the geographical places from which the influence toward a particular area is established.

In the late nineties, and during the beginning of the twenty-first century, a theoretical turn started to take place and was evident in the treatment of subjects, which, until then, were not developed in north-eastern Argentineand especially, the focus was placed on studying other aspects of the archaeological record. One of the subjects that started to be developed was the zooarchaeology, performing analysis of faunal assemblages, although usually coming from only one deposit(Acosta and Loponte, 2006; Feuillet Terzaghi, 2002; Pérez Jimeno, 1996; Santiago, 2002, among others).Only after the first results at the site level, inter-site information began to be integrated and this allows for making inferences at a regional level about subsistence, ranges of action and use of resources (see Acosta *et al*. 2010).

In this regard, the present study is considered to be a contribution to this regional trend, since it allows for making a comparison between the archaeofaunal records of 26 sites located in three areas of the Paraná River floodplain (Figure 1). In order to carry out the analysis, abundance indices are used, generating averaged values of faunal consumption, either for one of the analyzed sectors, or for a specific temporal block of past.

Figure 1: Areas of the Paraná River floodplain in North-South direction:a) Middle Paraná–Upper Sector (MP-US), b) Middle Paraná–Middle Sector (MP-MS) and c) Delta of the Paraná River and Coastal Shallows (DP&CS)

2. Environmental Framework

The Paraná River is the second longest river in South America and, due to its geomorphological and hydrological characteristics, is divided into four large sections: the Upper Paraná, the High Paraná, the Middle Paraná and the Delta. Although the study area covers the last two sections, due to an operational issue given by its wide expansion, the Middle Paraná, in turn, will be subdivided into three sectors. Thus, the space to be analyzed is constituted as follows: 1) Middle Paraná–Upper Sector (MP-US), 2) Middle Paraná–Middle Sector (MP-MS) and 3) Delta of the Paraná River and Coastal Shallows (DP&CS).This division also responds to environmental differences, which are reflected on the variability of the range of flora and fauna of each sector. The environmental basic concepts of the sectors that allow for the creation of archaeological expectations regarding the composition of the assemblages in each of the areas to be analyzed are detailed below.

One of the most important characteristics of the region is that it has a high environmental productivity, environmentally regulated by flood pulses of the Paraná River (Bóand Malvárez1999; Neiff 1999). This river has a climatic effect which results in the presence of a wedge of the Amazon Domain, which allows the introduction to the south of typically Amazonian animal populations (Cabrera, 1971; Ringuelet and Aramburu, 1957).Thus, the characteristic fauna of the whole area includes species from the pampas which possess certain adaptive plasticity, such as the Pampas deer (*Ozotocerosbezoarticus*) and other subtropical species, such as themarsh deer (*Blastocerusdichotomus*). These species, like those that are characterized by being adapted to water habitats, such as the coypu (*Myocastor coypus*), the capybara (*Hydrochoerushydrochaeris*), the neotropical otter (*Lontralongicaudis*), the Yacare caiman (*Caiman* sp.) and side-necked/toadhead turtles(*Phrynops* sp. and *Hydromedusa* sp.)(SPANP, 1997), are characteristic of the entire river area of the Paraná River and, for this reason, they are found in the three sectors considered in this study. Another characteristic feature of the whole sector is the high concentration of fish, represented by two main orders: Characiformes and Siluriformes.

The former include the Dorado (*Salminusmaxillosus*), the *sábalo* (*Prochilodusplatensis*), the *boga* (*Leporinusobtusidens*), the Tiger Fish (*Hopliasmalabaricus*), the pacu(*Piaractusmesopotámicus*), and *mojarras* (*Aphyocharax*spp.,*Astyanax* spp.); and the latter include the Spotted sorubim (*Pseudoplatystomacorruscans*), the catfish known as *patí* (*Luciopmeluduspati*), the yellow catfish and the South American catfish known as *bagre* (*Pimelodusclarias* and *Rhamdiasapo*, respectively), the granulated catfish (*Pterodorasgranulosus*), the white catfish or commonly known as*moncholo* (*Pimelodusalbicans*) and the common pleco (known colloquially as a sucker fish or as *vieja del agua* in Spanish) (*Plecostomuscommersoni*) (Ringuelet, 2004).

The sites that are located further north correspond to the MP-US and zoogeographically are part of the Neotropical Region and the sub-district of Chaco province, which is the richer site due to its biodiversity (Cabrera and Yepes 1940). It is characterized by the presence of several species that are not present in the regions of the middle sector and in the Delta, such as for example, the black howler monkey (*Alouattacaraya*), the ocelot, also known as the dwarf leopard (*Felispardalis*), the maned wolf (*Chrysocyonbrachyurus*), the brown brocket deer (*Mazamagouazoubira*) and the Braziliantapir (*Tapirusterrestris*), among others.

The sites that are situated within the MP-MSin zoogeographical terms are part of the Pampean domain (Guayana-Brazilian sub-region, Neotropical region)(Ringuelet 2004) and cover both the Pampean sector and the transitional area from the latter to the sector of the Paraná Delta and Islands (Peña 1997). The sites of the DP&CS are part of the Paraná Wetland [according to the Ramsar Convention on Wetlands of International Importance, Ramsar (2006)], and are located within the ecoregion Paraná flooded savannah (*sensu*Burkart*et al.* 1999). Both environments are characterized by typical pampas species, such as the *Caviaaperea* and the *Chaetophractusvillosus*; but also by distinctive species already described, which have adapted themselves to an aquatic life. Among them, the most outstanding species are the capybara (*Hydrochoerushydrochaeris*) and the coypu (*Myocastor coypus*). With regard to the wildlife that can be found in the most southern part of this sector, besides the aforementioned fauna, the following species can be seen: the pampas fox (*Pseudalopexgymnocercus*), theplains vizcacha (*Lagostomusmaximus*) and the White-eared Opossum (*Didelphisalbiventris*) (MAGIC, 1997).

The most characteristic birds of the area include the firewood-gatherer (*Anumbiusannumbbi*), thornbirds (*Phacellodomus* sp.) and spinetails (*Synallaxis* sp.), as well as the short-eared owl (*Asioflammeus*). Regarding fish, they are more abundant than in the MP-US, although the pattern of predominance of the two orders which were mentioned for the northernmost sector is repeated.

3. The Archaeofaunal Record of Theparaná River Floodplain

Each of the sectors of the floodplain has varied data on what has been human occupation in the past. Taking into account that the purpose of this section is to summarize the information generated for each landscape, we will focus on the development of the models that refer to the space occupation and subsistence of the populations which inhabited the area.

With regards to the northernmost sector of the Paraná River floodplain, within the MP-US, the oldest deposit corresponds to *La Lechuza*site, which has a radiocarbon date of 1760 ± 60 (Cornero*et al*. 2010). The human occupation model for this area was proposed by Pérez Jimeno (2007) for groups that had occupied the area after 1,500 years BP. The author argues that it would have been inhabited by semi-settled human groups linked closely to lentic environments generated by the dynamics of the Paraná River. In turn, the groups, would have had a specialized technology (ceramic, bone, lithic technology, in some sectors), allowing them to base their subsistence on fishing, mammal hunting (mainly, deer and rodents) and shellfish harvesting. Lentic environments would have been intensively exploited during periods of low river level, since during periods of flooding populations were divided and moved westward, toward ecotonal areas, or to the highlands on the left side of the Paraná River (Pérez Jimeno, 2007).

In the assemblages of sites which were studied by Pérez Jimeno, an exploitation of cervids, such as the *Blastocerusdichotomus* and the *Ozotocerosbezoarticus*, rodents (*Hydrochoerushydrochaeris* and *Myocastor coypus*) and fish, is reflected. However, there are some differences in the composition of the assemblages which has been explained in terms of space (Sartori and Pérez Jimeno, 2012).

Despite the fact that it is estimated that fishing was a significant activity for the inhabitants of this sector, who would have exploited this resource in the nearest bodies of water but not in the main riverbed of the Paraná River(Pérez Jimeno 2007), it is interesting that the dominance of the fish in the assemblages decreases at the sites located outside the floodplain(Satori 2013).

For the area corresponding to the PM-MS on the side of Entre Ríos province, Bonomo *et al*. (2010, 2011) argue that occupations would have been mainly in fluvial environments, accessing by water using canoes and where the water networks integrated the circulation systems between the sites (Bonomo *et al*. 2010; 2011b). In turn, they propose that many of the sites would have been located on human-made earthen mounds (locally called "*cerritos*"), which would have been intentional ground elevations (Bonomo*etal.* 2010. Therefore, they resume a discussion that has already been generated by archaeologists at the end of the nineteenth century and at the end of the twentieth century (see De Aparicio 1936);on one hand, the nature of these constructions was subject of debate among archaeologists and, on the other hand, the use that was given to them (see Serrano 1931). To Bonomo and the co-authors, if their hypothesis is confirmed –hypothesis also proposed for the Lower Delta of the Paraná River (Torres 1911; Zeballos y Pico 1878) - this area would be the southern boundary of a type of architecture (earthen mounds) which is abundant in the lowlands of South America.

With regards to the archaeofaunal remains of this sector, Bonomo indicate that they are usually poor, since, from 15 sites, merely 4,095 bone and malacological remains were recovered (Bonomo*et al*. 2011b). The authors deduce that the groups which inhabited the area would have had an aquatic-based diet. The sites have several *taxa*; the species that stand out mostly for their abundance and recurrence would be*Myocastor coypus*, *Hydrochoerushydrochaeris*, *Blastocerusdichotomus*, *Caviaaperea* and carnivores. *M. coypus* is the species most represented of all assemblages, while the consumption of siluriformes and freshwater clams seems to have also played a prominent role in the diet (Bonomo *et al*. 2010; Bonomo*et al*. 2011b).

To the MP-MS, but on the side of the Santa Fe province, there are lines of research which have been proposed and are related to certain archaeological expectations that are being developed by one of the authors of this manuscript.

They suggest that by 1,000 years BP and until the moment of contact between Europeans and Indians, there would have been a recurrence in the occupation of insular areas and sectors in the boundary of the Paraná River floodplain. The latter would have been located on high grounds with a clear view and close to watercourses, but not to those which were flooded. This allowed hunters-gatherers to obtain supplies of vital resources such as water, firewood and great amount of vegetables and potentially consumable animals (Sartori 2008, 2010a).

Moreover, the insular areas would have been strongly occupied due to their access to wildlife resources, principally, the access to obtain fish in low-risk environments which greater concentration. That is to say that there would be a hierarchy in the occupation of certain types of spaces to the detriment of others, which would be occupied frequently over time and would present a symbolic area, established mainly by the presence of multiple burials.

Regarding wildlife resources for the area, they reflect the diversity of exploited *taxa*, among which are those that have a highranking (i.e., *B. dichotomus, O. bezoarticus* and *H. hydrochaeris*) and a low ranking(i.e. *M. coypus*, Dasypodidae and fish) in the hierarchy. It was also corroborated in the different assemblages, the use of seven species, including mammals and birds which had been certainly used, due to the fact that they havecharacteristics associated with human activity (cut marks and/or thermal changes). In addition, if in this count the macro taxon of fish is included, the number increased even more, since ten species were documented in the different records, among them, the most frequently seen species were catfishes (*Pimelodusalbicans* and *Pimelodusmaculatus*) and the granulated catfish (*Pterodorasgranulosus*).The composition of the assemblages allows for making inferences based on the abundance and presence/absence of certain *taxa*. In this respect, the variability of the species present indicates a predominance of fish in the insular areas, whereas the areas in the boundary reflect a greater use of mammals. However, in both cases, individuals would be choosing strategies to reduce or minimize the risk by including low-ranking prey (coypu, Dasypodidae, and fish) in their diet (Sartori 2013).

Loponte and collaborators (Loponte *et al*. 1991, Loponte 2008, Loponte y Acosta 2004, 2008)based on paleoclimatic and geomorphic information, developed a theoretical model of space colonization for the Paraná Delta.

The earliest radiocarbon date for this area is from Playa Mansa with an age of 2,400 + 20 years BP (UGAMS 03302; Lama guanicoe; δ13C Corrected Age YBP±1s) (Sartori and Colasurdo 2011).

For these situations, the archaeological expectations are groups which reduced their mobility and have an exploitation of large-sized mammals (e.g. Cervidae family).Nevertheless, the emphasis on catching fish had already started, thus, subsistence was based on fluvial-lacustrine resources. Over time, this would go changing, since there is a further intensification in the environmental exploitation, which was reflected on an increased use of low-ranking resources caught in mass (in particular, fish). In addition, the record shows a component of foods of vegetable origin in the diet (Loponte 2008, 2010). This would have been generated through the development of small-scale farming practices, which would have provoked an increase in sex-age cooperation when obtaining food. This method would be implemented through a system of central settlement and it would entail a high residential stability. On the other hand, river mobility would have allowed the development of extended ranges of exploitation and exchange based on transportation of high volumes of products (i.e. grown food, farinaceous food, fishing, etc.). Moreover, at some point prior to 1,300 years ^{14}C BP, segmented mortuary spaces of the residential areas would have been generated (Mazza and Loponte2012).

With regards tothe archaeofaunal record of the sites corresponding to the Wetland of the Lower Paraná River, Acosta *et al*. (2011)state that there is a high degree of recurrence in the presence of fish, cervids and the *Myocastor coypus*. The authors, in turn, highlight the low representation of *Hydrochoerushydrochaeris*, which could answer those questions of cultural nature, such as for example, food taboos (Acosta 2005). The assemblages of most of the sites are dominated by fish, representing in some cases 80% and 90% of the NISP samples. Other *taxa* which had played an important role in the diet are *O. bezoarticus* and *B. dichotomus*, prey that have been exploited by a complete transportation ofthe carcases to the residential areas, where they would have also been intensively exploited (Loponte, 2008;Mucciolo, 2010).

4. Methodology

The analysis presented in this study is a regional scale analysis, covering different sectors of the Paraná River floodplain. To do that, data was compiled from 26 archaeological sites located in three sectors.

The definition of each assemblage was established based on the information that is published by the authors who performed the analysis for each sample, considering as a requirement that those samples consisted of over 100 specimens. For the analysis, the NUSP (*sensu* Lyman 2008) or indeterminate were discarded, and *taxa* were grouped in nine new categories. To the study of the archaeofauna, we considered only the macro taxon of vertebrates; those remains which belong to the category of invertebrates were excluded for the purpose of this study. The NISP of each assemblage, the indices of abundance (IA) estimated, the bibliographic reference sources, and the radiocarbon date for each assemblage are listed in table 1.

Table 1.NISP and Indices of Abundance (IA) of Each Assemblage

Abbreviation		Site	Date	TOTAL	Fish		Rodentia		Mammalia Indet.		Cervidae		Reptilia		Bird		Dasipodidae		Camelidae		Carnivoridae		Reference
				NISP	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	
CA	1	Cerro Aguara	530±70	23895	20094	0,84	2620	0,11	548	0,02	536	0,01	137	0,01	149	0,01	0	0,00	0	0,00	1	0,00	Perez Jimeno 2005 Santiago 2004
BP	2	Barrancas del Paranacito	S/d.	2962	598	0,24	1163	0,39	0	0,00	435	0,15	231	0,08	455	0,15	0	0,00	0	0,00	0	0,00	Perez Jimeno 1996
Cbin	3	Campo Binaghi	S/d.	341	48	0,14	79	0,23	154	0,45	28	0,08	10	0,03	0	0,00	15	0,04	0	0,00	3	0,01	Sartori y Pérez Jimeno 2012
PM1	4	Paraná Mini 1	S/d.	1557	824	0,53	78	0,05	265	0,17	63	0,04	220	0,14	34	0,02	0	0,00	73	0,05	0	0,00	Schmitz et al. 1972
LB	5	Los Bananos	1020±100	1240	532	0,51	199	0,16	201	0,16	38	0,03	79	0,06	36	0,03	55	0,04	0	0,00	0	0,00	Barboza y Martín 2012
LL	6	La Lechuza	1760±60	5613	321	0,06	2752	0,49	0	0,00	2412	0,43	27	0,00	23	0,00	50	0,01	18	0,00	10	0,00	Cornero et al. 2007
AA	7	Arroyo Arenal	S/d.	137	80	0,58	46	0,34	0	0,00	11	0,08	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	Nobile 1993
RSC	8	Río Salado Coronda	1305±48	179	46	0,26	71	0,40	52	0,29	1	0,01	0	0,00	0	0,00	2	0,01	5	0,03	2	0,01	Sartori 2008, 2010a, 2013
FP	9	Familia Primón	370±30	3431	959	0,28	220	0,06	1636	0,48	16	0,00	0	0,00	0	0,00	56	0,02	0	0,00	0	0,00	Sartori 2008, 2010a
LT	10	Las Tejas	1014±45	3445	3362	0,98	54	0,02	17	0,00	7	0,00	0	0,00	5	0,00	0	0,00	0	0,00	0	0,00	Sartori 2013
PD	11	Pajas Blancas	506±43	545	375	0,69	76	0,14	76	0,14	3	0,01	2	0,00	12	0,02	1	0,00	0	0,00	0	0,00	Sartori 2010b
CTV	12	Co. Tapera Vazquez	550±60	770	55	0,08	464	0,60	205	0,27	16	0,02	0	0,00	15	0,02	0	0,00	0	0,00	5	0,01	Donemo et al. 2011
BG	13	Bajada Guereño	S/d.	286	272	0,95	4	0,01	0	0,00	9	0,03	0	0,00	0	0,00	0	0,00	1	0,00	0	0,00	Escudero y FeuilletTerzaghi 2002
Pmm	14	Playa Mansa	2400±20	3456	1229	0,36	1028	0,30	980	0,28	74	0,03	0	0,00	0	0,00	126	0,04	17	0,00	2	0,00	Sartori y Colasurdo 2010
CLtz	15	Cerro Lutz	916±42	21862	21003	0,96	602	0,03	78	0,00	80	0,00	0	0,00	2	0,00	0	0,00	0	0,00	7	0,00	Arrizurieta et al. 2010
TCS2	16	Túmulo de Campana	1640±70	935	591	0,63	66	0,07	219	0,23	50	0,05	7	0,01	0	0,00	0	0,00	1	0,00	1	0,00	Acosta et al. 2010
RL	17	Río Lujan	S/d.	504	0	0	429	1	0	0	72	0	0	0	1	0	0	0	2	0	0	0	Salemme 1987
Lvis	18	Las Vizcacheras	1090±40	16687	14696	0,88	1547	0,09	400	0,02	36	0,00	6	0,00	5	0,00	0	0,00	2	0,00	0	0,00	Acosta et al. 2010
Ah	19	Anahí	1020±70	11063	8395	0,76	758	0,07	1476	0,13	304	0,03	69	0,01	42	0,00	1	0,00	3	0,00	15	0,00	Acosta et al. 2010
ME	20	Médanos de Escobar	1752±33	472	155	0,33	41	0,09	257	0,54	16	0,03	0	0,00	0	0,00	0	0,00	2	0,00	1	0,00	Loponte et al. 2013
LBS2	21	La Bellaca 2	580±80	37623	33536	0.89	3444	0.09	388	0.01	204	0.01	6	0.00	23	0.00	9	0.00	1	0.00	12	0.00	Acosta et al. 2010
Ga	22	Garín	1060±60	3452	1788	0.52	910	0.26	374	0.11	326	0.09	28	0.01	22	0.01	0	0.00	1	0.00	3	0.00	Acosta et al. 2010
LBS3	23	La Bellaca 3	S/d.	1896	1632	0.86	198	0.10	50	0.03	14	0.01	1	0.00	1	0.00	0	0.00	0	0.00	0	0.00	Acosta et al. 2010
Agua	24	Arroyo Guazunambí	940±60	1901	1210	0,64	376	0,20	222	0,12	66	0,03	8	0,00	1	0,00	0	0,00	15	0,01	3	0,00	Acosta et al. 2010
LBS1	25	La Bellaca 1	1110±70	4213	3567	0,85	338	0,08	278	0,07	30	0,01	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	Acosta et al. 2010
Asar	26	Arroyo Sarandí	1290±40	5672	4658	0,82	748	0,13	230	0,04	26	0,00	6	0,00	0	0,00	0	0,00	3	0,00	1	0,00	Acosta et al. 2010
TOTAL				154138	120236	0.78	13396	0.12	8105	0.05	4673	0.03	837	0.01	806	0.01	315	0.002	144	0.001	66	0.0004	

Methodologically, in order to produce an analysis that contributes to evaluate trends in terms of space, the aggregation of taxonomic categories was performed and they were included under the level of Family or even class (as suggested by Lyman, 2003). To this end, we collected the zooarchaeological data that is published for each of the areas to be analyzed. Once this was done, we proceeded to:

-Geo-reference the sites which the wildlife assemblages come from.
-Form new groups through the clustering of taxa in 9 new categories (Fish, Rodents, Mammalia Indet., Cervids, Reptiles, Birds, Dasypodidae, Camelidae, Carnivoridae).

-Calculate the indices of abundance (IA) for each of the mentioned resources, following the proposal ofLyman (2003). The values of the indices show normalized results, ranging from 0 to 1. Those values greater than and equal to 0.5 indicate a predominance of the resource, and those less than 0.5 and close to 0 indicate an absence of the resource (Lyman 2003, 2008). The formula used to calculate the abundance index was the following:

∑NISPpeces/(∑NISPpeces+∑NISPaves+∑NISPcérvidos+∑NISProedores+∑NISPdasypódidos+∑NISPreptiles+∑NISPCamelidae+∑NISPcérvidos+∑NISPCarnivoridae)

-The results were presented graphically using the GIS, by means of the ArcGIS 10.1 programme. With the accurate data of the IA, an interpolation of data was performed for each resource, through the regular procedure called Inverse Distance Weighting (IDW), using the aforementioned programme(Santiago and Vazquez 2013).

-Maps were created in raster format, called Bonescapes according to the method of Santiago and Vázquez (2013), which derived from Isoscapes: Isotopic Landscapes, (*sensu* West *et al*. 2010). Finally, we proceeded to cut the raster maps (these maps are continuous surfaces where each pixel contains one numerical datum and in the case of Bonescapes, data is the values derived from the indices of abundance) with a vector map of the Paraná River floodplain.

It should be noted that the faunal data for the Paraná River floodplain is extensive, although the level of analysis used to study the different assemblages is heterogeneous, thus, being able to make fine-grained comparisons or integrative analysis, is a challenge. The variability of each analysis consists in quantitative and qualitative aspects. The differences within the former can be registered when the indexes, such as the MNI and the MNE, are calculated, sincethe criteria on which these estimates are based are not generally explained. For these reasons, and consistent with the objectives of the present study, we decided to perform the analysis based on the NISP. This will allow us to include more data.

However, we are aware of the difficulties of deriving subsistence patterns directly from these values, but we consider that the NISP is the only measure of taxonomic abundance available in most of the analysis, and its calculation is univocal.

Thus, this is appropriate for comparison purposes (Grayson 1984; Lyman 1994, 2003, 2008). Moreover, there are cultural taphonomic and methodological aspects that should have influenced the representation of the taxa of the assemblages in the floodplain. However, such differences are qualitative and quantitative and become blurred when making coarse-grained analysis, where the aim is to establish general trends regarding the existing variability in a region over time and to observe if there are differences in the presence/absence of certain species in a given space.

In order to render the assemblages comparable in terms of their composition, analyses of diversity were performed. What we are trying to establish is if there was exploitation more intensely of some taxon in particular, and in that case, what happened to the other species represented. Diversity can be understood as the number of species within a community and their relative abundance (Margalef, 1968).Three aspects can be included in this concept and should be considered: richness homogeneity and heterogeneity (L' Heureux 2008; Lyman 2008; Mengoni Goñalons, 2010). So as to perform these analyses, the statistical programme PAST was used and the Evennesseˆ H/S index was selected for homogeneity, the Simpson'sindex1 for the dominance analysis. If all species in a single sample have the same abundance, the index used to measure homogeneity should be the maximum (with a value of 1) and, therefore, it should decrease towards zero while relative abundances become less homogeneous.

5. Results

Of the 26 assemblages analyzed, 6 correspond to sites located in the MP-US, 6 to the MP-MS and 14 to the DP&CS. The represented *taxa* are distributed in a total of 26 species, from which were established as comparable the following categories: Fish, Rodents, Mammalia Indet., Cervids, Reptiles, Birds, Dasypodidae, Camelidae, Carnivoridae (see Table 1). They have been established according totheir presence in the record, which, in most of the cases,is due to anthropogenic agents.

All the assemblages totalled 154,138 faunal remains which belong to the macro taxon of vertebrates; the smallest assemblage consists of 137 remains and the biggest of 37,623 (Figure 2). Considering the total number of assemblages from broad taxonomic categories, we observe that the fish constitute, on average, for the entire Paraná River floodplain, 78%, whereas mammals represent 20% and birds together

with reptiles account for the remaining 12% (see Table 1). It should bepointed out that the first four categories of Table 1 (Fish, Rodents, Mammalia Indet. and Cervids) represent 98% of the faunal remains of the Paraná River floodplain.

If the composition of each sector is observed, in the area of the MP-US, the 6 sites have a total of 35,609 specimens with a mean of 5,934, while the median is 2.259 (Table 2). This area is the one that reflects a greater abundance of Cervids, Rodents, Birds and Reptiles.

The MP-MS has the lowest NISP in their records presenting a total of 8,507, a mean of 1,417 and a median of 657. The DP&CS is the area which exhibits the most robust samples, presenting a total of 110,022, a mean of 7,858 and a median of 3,454.

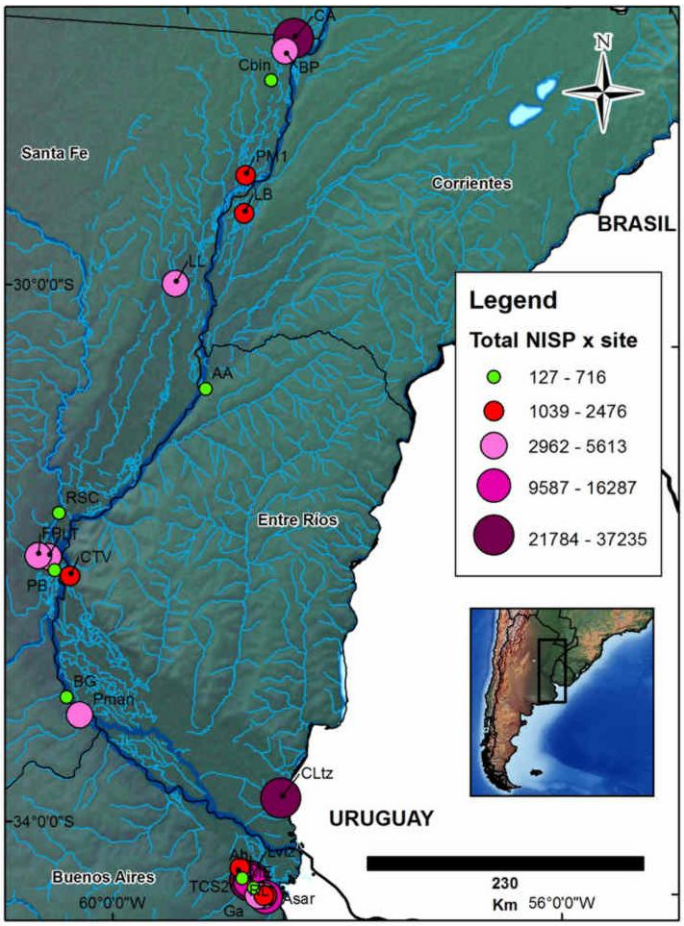

Figure 2: Total NISP per Site

Table 2: Comparable categories: Fish, Rodents, Mammalia Indet., Cervids, Reptiles, Birds, Dasypodidae, Camelidae, and Carnivoridae

Abbreviation	Site	TOTAL	Fish		Rodentia		Mammalia Indet.		Cervidae		Reptilia		Bird		Exotic fauna		Dasipodidae		Camelidae		Carnivoridae	
		NISP	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.	NISP	I.A.
MPH	Middle Paraná High sector	35609	22617	0,64	6891	0,19	1168	0,03	3312	0,09	704	0,02	677	0,019	15	4E-04	120	0,00	91	0,003	14	0,000
MPM	Middle Paraná middle sector	8507	4887	0,57	931	0,11	1986	0,23	54	0,01	2	0,00	32	0,004	544	6E-02	59	0,01	5	0,001	7	0,001
PD&CS	Delta & costal shoal	110022	92732	0,84	10574	0,10	4952	0,05	1307	0,01	131	0,00	97	0,001	0	0E+00	136	0,00	48	0,000	45	0,000
TOTAL		154138	120236	0,78	18396	0,12	8106	0,0526	4673	0,03	837	0,005	806	0,005	559	0,004	315	0,002	144	0	66	0,0004

Fish are present in 25 sites and, together, constitute the best represented resource in terms of NISP in the entire area (N=120236). If we focus on abundance, throughout the Paraná River floodplain, some differences can be observed.

In this regard, the most robust representations are observed in an increasing South-North direction (Figure 3). This aspect is consistent with the proportions in the presence of the other two resources which would have been essential to subsistence: rodents and cervids. This means that an inversely proportional trend is observed between fish and the other resources present. If attention is paid to each specific sector, the case of the DP&CS represents 77% of all the remains assigned to this Class. In that sector, fish greatly exceed 50% of the NISP of the assemblages in all cases (see Acosta and Loponte, 2008; Loponte, 2008).

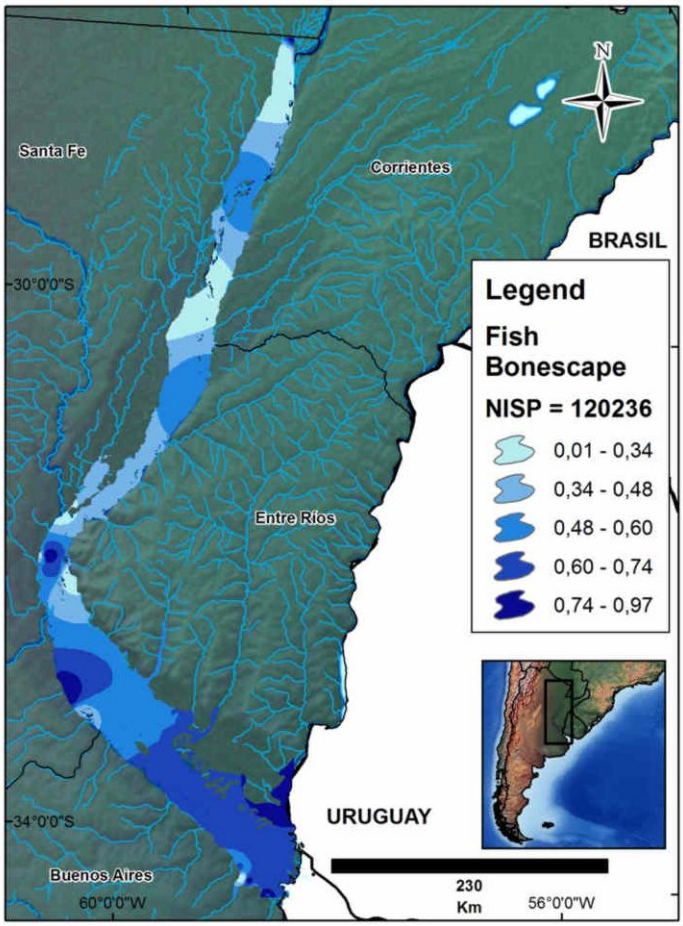

Figure 3: Bonescape of Fish

For the MP-MS, there is a decrease in fish abundance (IA=0.57) and also, into this area, a difference was detected between the composition of the insular areas and those which correspond to the sites located on the mainland. Such variation alludes to the predominance of mammals on the mainland, while in the insular area, fish predominate. This pattern is also observed in the MP-US, in which, however, the decrease of fish (IA=0.63) is accompanied by a marked increase in cervids, rodents and birds. Beyond this, it is precisely in the MP-US where the "Cerro Aguará" site is located; sitein which the highest number of fish species identified was recorded (N=23) (Musali*et al*. 2013), while in the middle sector and the Delta between 5 and 11 *taxa* belonging to the macro taxon of fish were recorded in all the assemblages.

Rodents (N=18,396) constitute, together with fish, the other resource widely represented throughout the Paraná River floodplain (Figure 4). Their remains contribute 12% within the overall NISP for the entire floodplain, and if it is taken into account that mammals as a whole constitute only 20% of the NISP, it can be observed the importance of these resources in the diet of hunters-gatherers-fishers. The spatial distribution of rodents as a broad category encompasses all sectors, and they are present in 100% of the sites, whilst a significant increase in their abundance is observed in the MP-MS (IA=0.10) and the MP-US (IA=0.19). Although, in the DP&CS, the most abundant NISPs for this Family are recorded, the indices of abundance are the lowest for the entire area (IA= 0.09), since fish resource is predominant.

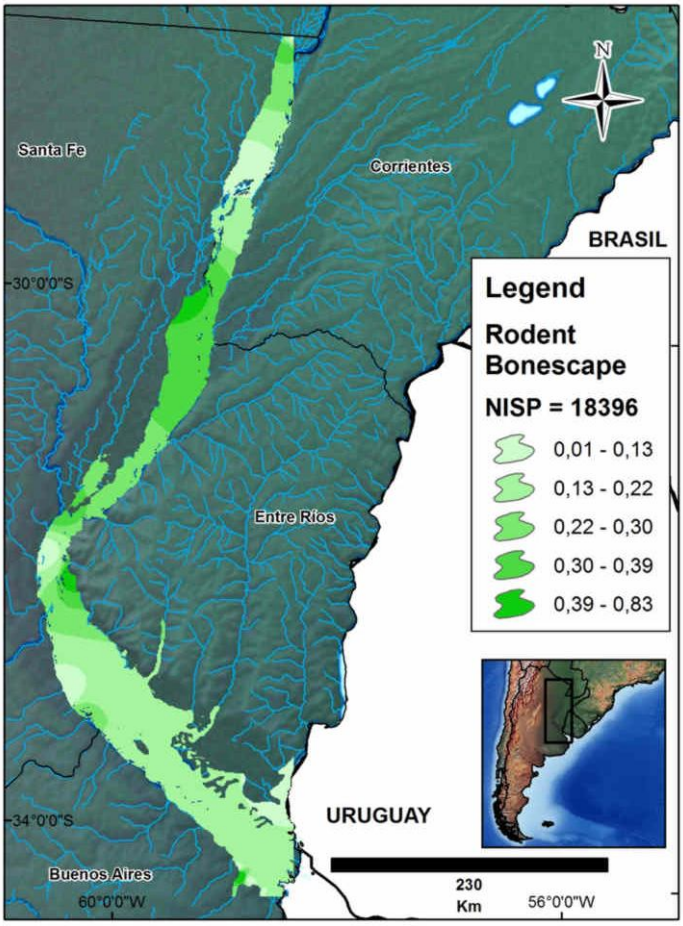

Figure 4: Bonescape of Rodents

Cervids, as a broad category, are present in all the sites of the three sectors, but unlike the two other most abundant resources, they present a marked decrease in terms of NISP (N=4673). Within the total of specimens for the floodplain, this category accounts for only 3%, reflecting values which are significantly lower than fish and rodents. The increase in the index of abundance of cervids occurs in South-North direction (Figure 5), presenting the records of the MP-US and 70% of the items identified for any of the three species that are recorded in the area. The representation decreases increasingly in the assemblages of the MP-MS, while it increases again in the DP&CS.

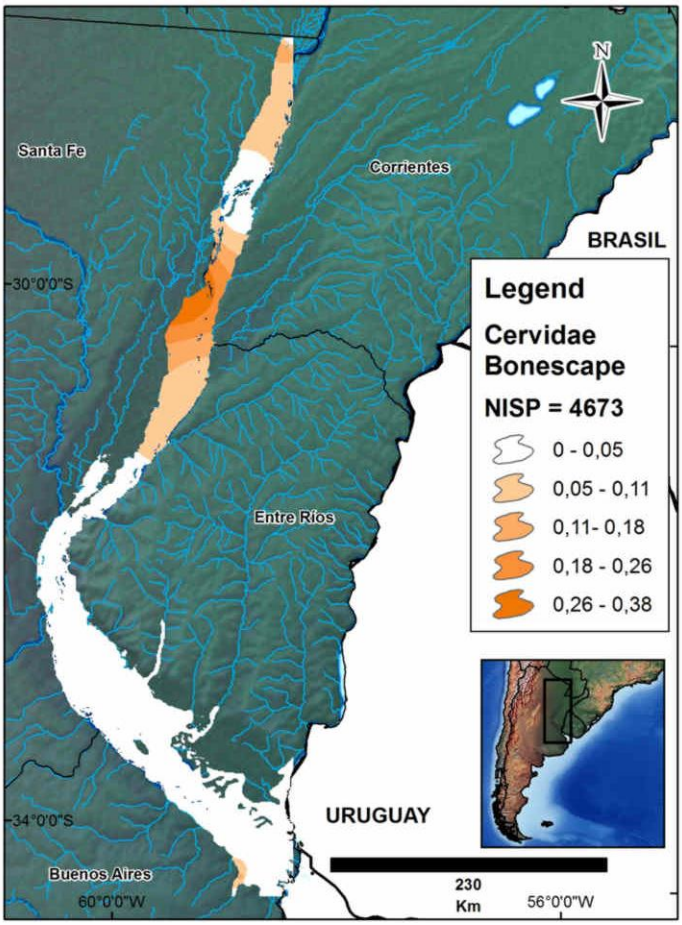

Figure 5: Bonescape of Cervidae

Among the other mammals which have low frequencies, there are the Dasypodidae (N=315) and carnivores (N=66), which are represented in deposits of the three sectors, although their abundance reflects a differential spatial pattern for the sets of the MP-US and the MP-MS. Dasypodidae are present in 35% of the assemblages and are distributed in four identified species. Their presence is greater at the sites located in the MP-MS(IA=0.06) and in the MP-US (IA=0.03), while in the DP & CS they are absent in most cases (IA=0.01). In the case of carnivores, of the different species that are represented, not all of them have evidence of having been exploited, while in the case of Dasypodidae, their presence is frequently associated with human beings who took advantage of them.

Birds (N=806), as well as rodents and cervids, have greater abundance in the MP-US, decreasing from North to South (Figure 6). As a macro taxon, their presence is recorded in 57% of the sites and they have not been identified at specific levels in most cases, due to the wide variability specific to the whole area and because of the lack of reference collections.

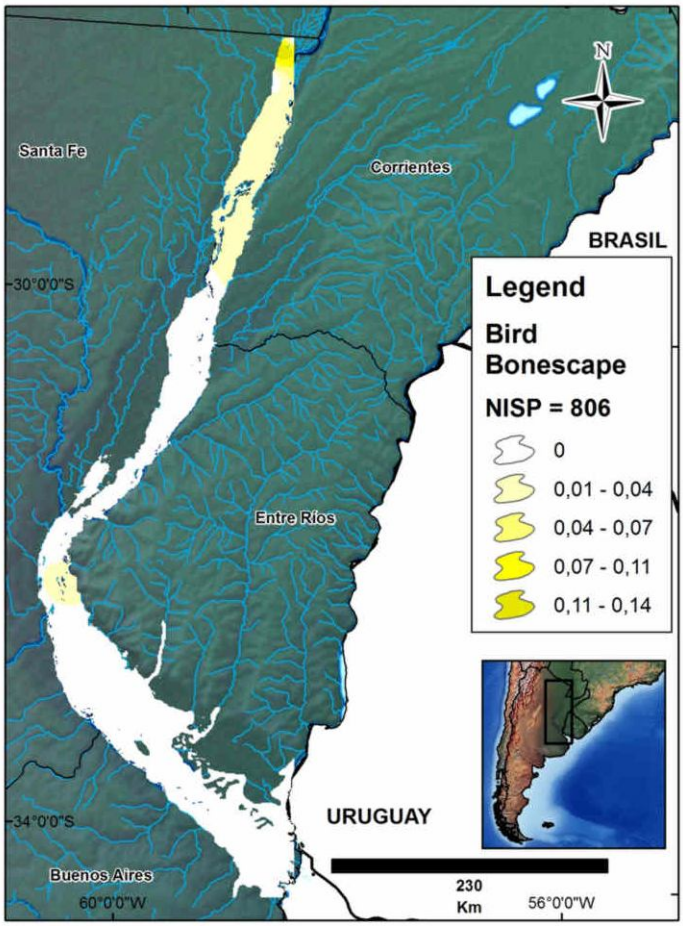

Figure 6: Bonescape of Birds

Finally, reptiles (N=837) show a greater abundance in the MP-US (IA=0.019) and the DP&CS (IA=0.001) is where they have a lower predominance (Figure 7). This is also reflected on the fact that the area of the MP-US has 84% of the remains assigned to this Class.

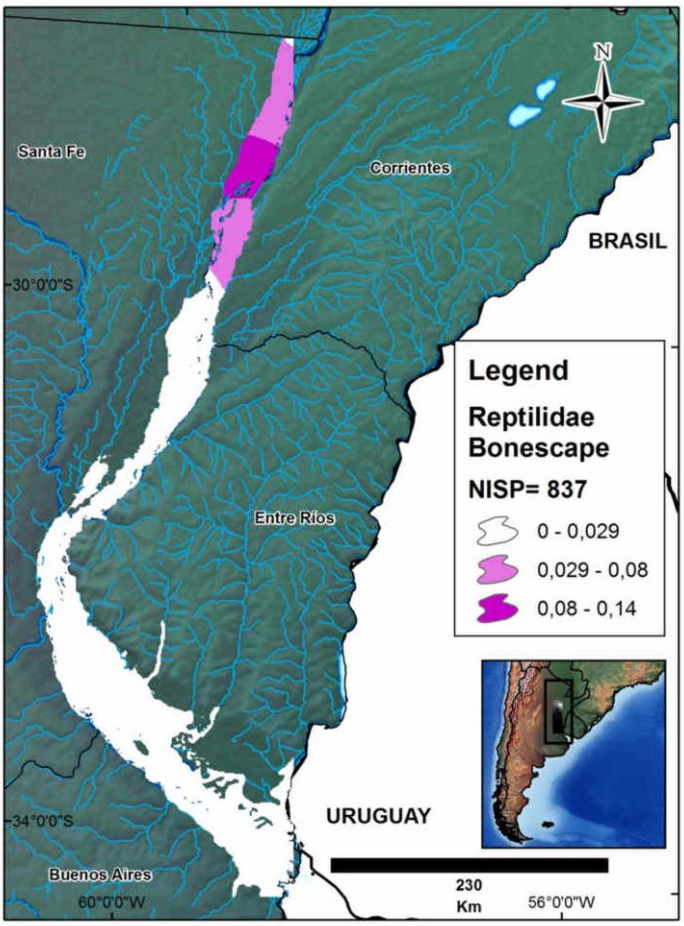

Figure 7: Bonescape of Reptilidae

The sector which has the largest number of NTAXA, on average (excluding the variability of the macro taxon of fish) is the MP-US of the Paraná River floodplain with 11.1; while the MP-MS (7.8) and the DP&CS (8.1) have similar values. The calculation of the trend, which was carried out considering the values by site and by area and reflected the greatest recurrence in the richness values specific to each sector, is: 9 for the upper sector, 8 for the middle one, while that of the Delta has the lowest value, which is 6. These values are consistent with the faunal variability which is intrinsic to each of the sectors of the floodplain, where the northern region stands out for its greatest richness.

In order to analyze the composition of the different assemblages in terms of their diversity, we proceeded with the estimate of homogeneity and dominance specific to each of the analyzed sections (Figure 8).

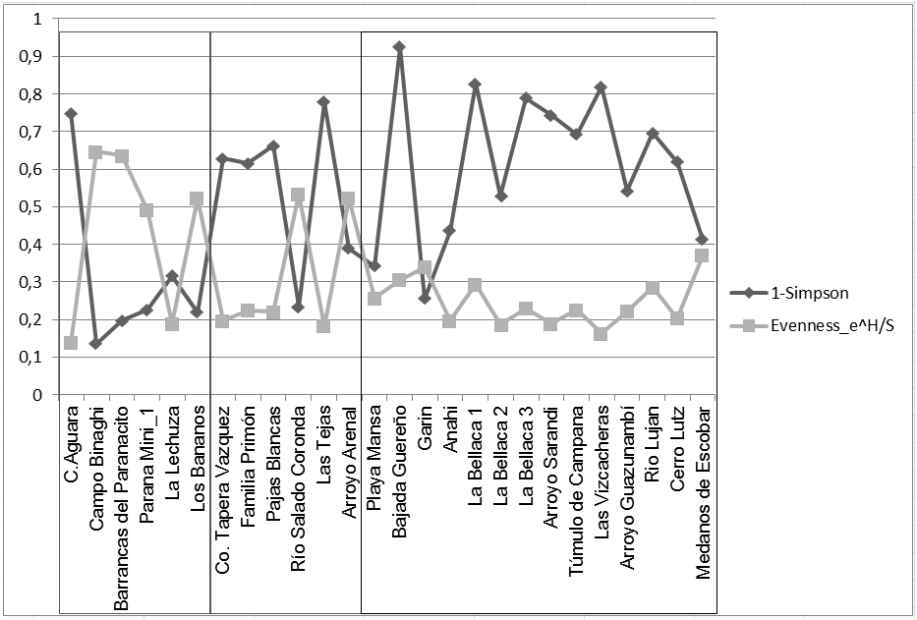

Figure 8: Homogeneity and Dominance Index per Site

Considering the composition of the assemblages of each area comparatively, it is observed how the most homogeneous are presented in the MP-US, while the most heterogeneous occur in the DP&CS. Generally speaking, only 23% of the assemblages have homogeneous samples, in which the sites of the MP-US have the values that are closest to 1. With respect to how individuals are distributed within each taxonomic category, the samples with the greatest dominance of a *taxa*over the rest taxa correspond to assemblages of the MP-MS and the DP&CS, in which there is a predominance of fish. In the MP-US(except for the "Cerro Aguará" site), although the samples are homogeneous, the low dominance indicates that all the identified species have a good representation regarding the amount of specimens assigned to category. In the MP-MS and in the DP&CS, then, inhomogeneous samples are produced, samples in which there is a differential distribution of the elements in a few specific categories.

6. Discussion

Given the environmental characteristics of each of the areas in which the sites are located (characteristics reflected on an increase in biodiversity in south-north direction), it would be expected that there are differences in the preponderance of the resources exploited in each sector. This means that beyond the variations in the composition of each particular assemblage, the expectation is that there will be trends observed in each sector, which would come with the range of fauna. In order to produce an analysis in terms of space, the GIS was considered a tool to visualize the trends in each of the study areas and it allows for their comparison. The results described in the previous section enabled the observation of recurrences regarding the broad taxonomic categories dominating the assemblages in each sector. Although this is extremely useful for the discussion of the resources which would have had a central role in the subsistence of the groups constituted by hunters-gatherers-fishermen in the region, this should be taken into consideration. Due to the fact that the categories of analysis include different *taxa,* it becomes necessary to perform a finer-grained analysis into the interior of each sector, since there are variations reflecting the exploitation of certain species in particular to the detriment of others.

Regarding the fish present, at macro-regional level, trends can be established since, in the sites of the DP&CS, the granulated catfish (*Pterodorasgranulosus*) is the prey which dominates the assemblages and catfishes, known as *bagres*, are absent or poorly represented (Loponte2008; Musali 2010). In contrast,in the sites located on the MP-US and MP-MS, catfishes(*Pimelodellalaticeps*, *Pimelodusmaculatus* and*Pimelodusalbicans*) and other species identified in the different assemblages (such as for example, *Plecostomuscommersoni, Hoplosternumlittorale* and *Trachelyopterusgaleatus*) have a greater presence within the NISP% of the samples (Musali*et al*. 2013;Sartori 2013).In spite of this pattern, the results should not be considered as absolute trends, since it is likely that fragmentation, lack of diagnostic elements[2]and the wide variety of species in an area with high diversity are covering a greater specific diversity in the assemblages. Therefore, these trends should be contrasted while new contexts are deepened and identification techniques specific to "fish" Class are improved.

Rodents are the second most exploited resource in terms of NISP and they are found in all sites, even though, it should be noted that among the potentially consumable species and those with evidence of having been consumable, differences are registered. The coypu has the most homogeneous distribution, being found in all assemblages and represented by a large amount of remains, while the capybara is found in 54% of the assemblages and with low NISPs; this reflects a low exploitation of this rodent which far exceeds the coypu in appearance. Its low NISP and its low presence in the sites have led to consider one restriction on its use (Acosta, 2005), especially, in the area of the lower Paraná and the Delta. Nevertheless, for the middle area, Sartori (2013) suggests that variations in their representation might be given in terms of space, since this animal is better represented in insular areas (Sartori, 2013).

Thus, in the northernmost area, Pérez Jimeno (2007) and Santiago (2002) conclude that this large rodent would constitute part of the diet of those groups of hunters-gatherers-fishers. This fact is also supported by the data of reports, articles and ethnographic studies, carried out among indigenous groups from the Gran Chaco, which record the consumption of this species.

With regards to the three identified species of cervids, in all assemblages, one of them is recorded, even though there are differences among the most abundant species. The largest species –the marsh deer (*Blastocerusdichotomus*)- is prevalent throughout the area (since it is present in 88% of the sites). According to abundance, the species that follows is the pampas deer (*Ozotocerosbezoarticus*), which is the second largest species and it has a smaller representation, since it is present in 73% of the assemblages. Finally, the *Mazamaguazoubira*is the smallest cervid and is only represented by 8% of the analyzed assemblages. Probably, the preponderance of the marsh deer will be a result of the spatial issues that are related to the ecological requirements of this species and of the other two which inhabit the region under study.

Thus, it should be noted that there are differences in the types of habitats among the three species. *Blastocerusdichotomus* are frequently seen in areas located close to lakes, rivers and marshy areas with tall grasses that provide them food and cover them from predators (Pinder and Grosse 1991). However, *Ozotocerosbezoarticus* is adeer typical of plains, open environments, without arboreal vegetation or with few islets composed of xerophytic or semi-xerophytic trees.

That is to say that the presence of the latter species, in some assemblages, would show links with the Pampas, close to the Paraná River flood plain. Nonetheless, the presence of the marsh deer shows narrower ranges of action linked to the insular area.

Camelids, as well as the presence of *Rhea americana*, would be one of the animals which show contact with drier and not flooded areas. In this regard, it is noteworthy the fact that the three species (deer, rheas and camelids) are always related to each other: In all the cases in which *R. Americana* (ñandú) is present –species that has the lowest frequency-, the other two species are also present. This bird, which is the largest one in America, is found in a northern siteand in four sites that corresponds to the Coastal Shallows, near to the area where the "Pampa Ondulada" begins, while in the middle area, it has a total absence.

Thus far, we have discussed the preponderance of resources in terms of space and this helped to establish that, in general terms, the most represented resources are fish and, according to abundance, they are followed by rodents, and then,by deer. Among these, the coypu and the marsh deer would have had the main role in the diet/subsistence of the human groups in the area. This reflects the exploitation circuits enclosed by the riverside environment, while in certain sectors (sites located in the continental sector), it is registered a contact with the resources typical of the Pampas. In spite of this, in most places, fish represent over 50% of the NISP, whereas, when fish decrease, rodents and cervids increase and, in some cases, particularly in the north, a greater diversity occurs between the *taxa*, thus,there is, for example, an increase in reptiles and birds. In addition to this trend, it remains to consider if there are temporal variations regarding the predominance of the most exploited resources.

In order to analyze this aspect, the time period comprised in this study (late Holocene) was divided considering the dates which belong to the earliest times (between 2,400 and 1,700 years BP), intermediate times (between 1,290 and 940 years BP) and late times, which even reach the European-Indian contact (between 650 and 370 years BP).

This time distribution is significant due to the fact that it allows the investigation of the variations produced in a chronological period which might be linked to the changes in the subsistence strategies. To that end, we proceeded to cross the dates with the dominance of a resource on the different assemblages (Figure 9).

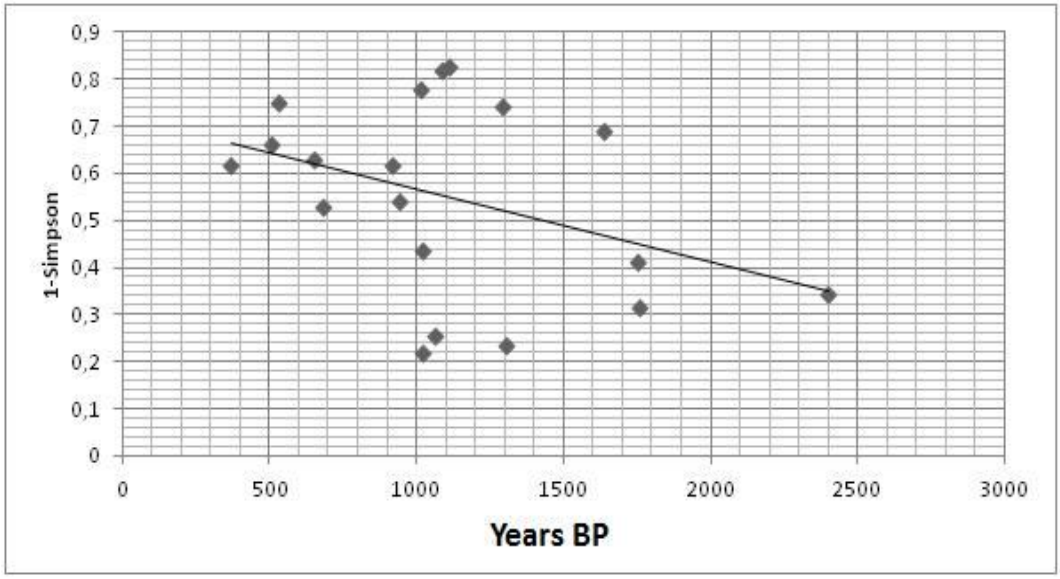

Figure 9: Dominance of One Resource through the Years

As shown in Figure 9, there is an increasing trend (although a slight one) of a greater dominance of a resource (values closer to 1) in the late assemblages, resource which, as discussed above, corresponds to fish. This would be indicating a specialization which would have already started at least 1,000 years BP and this is coincident with the proposed models for the area (Loponte 2008;Pérez Jimeno, 2007; Sartori, 2013).

7. Conclusions

This study makes the summary of the archaeofaunal data available for the floodplain and delta of the Paraná River. Studies in this area have increased significantly over the past 15 years and reflect the effort of several research teams which made an important elaboration of information. This is extremely positive since it allows researchers to carry out integrated studies based on fine-grained information already generated.

Throughout the area of the Paraná basin, there are a lot of species, among which 26 are represented (besides the macro taxon of fish) in the zooarchaeological records. However, fish and two species of rodents and deer represent the larger amount.

This shows a recurring specialization for the entire area, although, if each of the sectors is observed in detail, there are exceptional cases in which birds, reptiles or Dasypodidae would have had certain economic importance. GIS implementation at macro-regional scale enabled the assessment of the variability in the faunal exploitation of the area and it would have been based on the same species, both in northern and southern sectors. Therefore, it can be observed how –beyond the environmental features of this sector in the Paraná basin-the differences in faunal representation are established in the greatest-lowest predominance of fish in the assemblages.

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